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Feasibility and reliability of the modified Berg Balance Scale in persons with severe intellectual and visual disabilities

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Abstract

Background The purpose of this study was to determine the feasibility and reliability of the modified Berg Balance Scale (mBBS) in persons with severe intellectual and visual disabilities (severe multiple disabilities, SMD) assigned Gross Motor Function Classification System (GMFCS) grades I and II.

Method Thirty-nine participants with SMD and GMFCS grades I and II performed the mBBS twice with 1-week interval. Feasibility was assessed by the percentage of successful measurements per task and of the total score. First, test–retest reliability was determined by intraclass correlation coefficients (ICC) for each task and for the total score of all tasks combined. Second, level of agreement between test–retest scores was assessed with the proportion of equal scores for each task. Finally, internal consistency of the distinct tasks was assessed by Cronbach's alpha.

Results The results indicated that 92% of the measurements by the mBBS for all selected tasks were successful, indicating that the mBBS is a feasible

instrument for the tested target group. ICC for the test–retest of the total score was 0.95. The proportion of equal scores for test–retest of the tasks was 0.80 or more, except for tasks 9 and 10. Cronbach's alpha of distinct tasks was 0.84. Test–retest reliability of tasks 9 and 10 was not acceptable.

Conclusions Feasibility of all tasks and test–retest reliability of 10 out of 12 mBBS tasks is acceptable. The mBBS is a both feasible and reliable test for evaluating the functional balance of persons with SMD and GMFCS grades I and II.

Keywords balance, locomotor assessment, locomotor skills, severe intellectual disabilities, visual impairment

Introduction

Locomotor skills in people with intellectual disabilities (ID) are characterised by decreased accuracy, variation and active exploration when compared with locomotor skills of those without ID (Van Erkelens-Zwets & Kars 1988). Adults with mild or moderate ID are often found to have sensory integration problems (Carmeli *et al.* 2008) and a sedentary lifestyle (Frey & Chow 2006; Temple *et al.* 2006; Lahtinen *et al.* 2007). IQ level is

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reported to be the main indicator of overall performance on motor tests (Wuang *et al.* 2008). Furthermore, a study by Wuang *et al.* (2008) indicated that verbal comprehension and processing speed indexes specifically were reliable predictors of gross and fine motor function. Shinkfield *et al.* (1997) reported that persons with ID suffer from inadequacies in both perception and motor-reproduction. Moreover, data on force platforms and posturography have outlined the characteristic movements of those with ID (Bodfish *et al.* 2001).

Like individuals with ID, persons with visual impairments also display poor performance on locomotor skills (Houwen *et al.* 2008) and have low levels of habitual activity (Hopkins *et al.* 1987). Compared with normal children, children with impaired vision exhibit differences in motor control which are not directly related to poor vision (Reimer *et al.* 2008). Reimer *et al.* (2008) found that 'children with visual impairment seemed to have more difficulties with calibrating the sensory information and specifically, they made larger errors along the lateral direction, when the target was not visible'. As a result, persons with visual impairments often display poor physical fitness compared with persons with normal eyesight (Häkkinen *et al.* 2006; Seemungal *et al.* 2007).

Consequently, individuals that have both intellectual and visual disabilities are particularly at risk concerning the potential development of deficits in both locomotor skills as in daily functioning (Evenhuis *et al.* 2009). The high prevalence of visual impairment and blindness among persons with severe or profound ID suggests this risk is serious (Van Splunder *et al.* 2006). For complex reasons, individuals with ID frequently fall (Hale *et al.* 2007). Visual deficits are identified as a potential factor for falling (Hale *et al.* 2007). Furthermore, people with visual disabilities exhibit decreased balance (Häkkinen *et al.* 2006; Seemungal *et al.* 2007). The combination of these findings puts forward the suggestion that persons having both intellectual and visual disabilities are likely to have decreased balance. It is imperative to gain insight into the severity and prevalence of balance problems in this population. In addition, interventions need to be designed to improve balance control, physical activity and, eventually, participation in daily life.

As to date, it remains unclear which specific balance test is feasible and reliable for testing subjects with severe intellectual and visual disabilities. It is certain, however, that many of the standardised outcome measures to quantify balance capabilities commonly used in physiotherapy are not applicable to participants with ID (Hale *et al.* 2007; Hilgenkamp *et al.* 2010). If balance tests are to be used to assess persons with severe or profound intellectual and visual disabilities (severe multiple disabilities, SMD), it follows that assessing the feasibility of these tests is a priority. If a participant does not understand the tasks of a certain test, the test will automatically fail to provide a realistic impression of the functional balance of the participant. In that case, the test will be invalid.

It follows that test instructions for individuals with both intellectual and visual disabilities require our special focus. Two hindrances have to be taken into account. First, as a result of severe or profound ID, test instructions are often not understood or with great difficulty (Hale *et al.* 2007) [ICD-10 (WHO 1992)]. Second, individuals with visual disabilities cannot see how test tasks are to be performed (Van Splunder *et al.* 2006), rendering showing them how to perform the task at hand useless.

Out of the several balance tests described in the literature, only a couple are feasible for our target group. Tests were assessed on the basis of the difficulty of test instructions and the functionality with regard to the target group. The following tests seemed adequate at first sight: the Functional Reach Test (Duncan *et al.* 1990), the Timed Up and Go Test (TUG, Podsiadlo & Richardson 1991), the Performance Oriented Mobility Assessment (POMA, Tinetti 1986), the Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT-4) (Rossiter-Fornoff *et al.* 1995) and the Berg Balance Scale (BBS) (Berg 1989).

The Functional Reach Test (Duncan *et al.* 1990) measures the difference between a subject's arm length and his or her maximal forward reach, as the subject sits or stands in a stationary position. For young subjects without disabilities, this test has a test-retest reliability of 0.89 and an inter-rater agreement of 0.98. Furthermore, this test is strongly associated with measurements of centre-of-pressure excursion, having a correlation coefficient of 0.71. However, after a few practice sessions, the conclu-

sion was reached that the Functional Reach Test is not suitable for the target group as they have difficulty understanding how to perform this task.

Podsiadlo & Richardson (1991) modified the Get Up and Go Test (Mathias *et al.* 1986) by incorporating a timed component and coined it the Timed Up and Go Test or TUG. In this test, the subject is observed and timed while he or she rises, walks, turns around and sits down again. The TUG has a test-retest reliability of 0.99 and an inter-rater agreement of 0.99. Moreover, TUG times correlate moderately well with the Barthel Index at 0.78 and scores on the BBS at 0.81. However, the speed of movement is influenced by a subject's comprehension time and reaction time, two factors that are inherently affected by intellectual and physical disabilities (Van Erkelens-Zwets & Kars 1988; Hale *et al.* 2007). Therefore, the abilities of persons with SMD are underestimated if time is used as an outcome measure.

The POMA (Tinetti 1986) evaluates balance when a subject stands, stands up, sits down, sits and walks. Smits-Engelsman *et al.* (2000) concluded that the sensitivity of the POMA is less than the sensitivity of the BBS, making the latter the preferred test.

The FICSIT-4 (Rossiter-Fornoff *et al.* 1995) comprises of four tests of static balance. These tests evaluate the ability to maintain balance in parallel, semi-tandem, tandem and one-legged stances, alternately with eyes open and eyes closed. Test-retest reliability was good ($r = 0.66$) as was validity, showing moderate to high correlations with physical function measures and three balance assessment systems. However, after a few practice sessions, it became clear that the subjects failed to understand the semi-tandem and tandem components of the FICSIT.

The BBS (Berg 1989; Berg *et al.* 1989, 1992) evaluates a subject's functional balance during daily situations – such as when the subject stands up, stands still, sits down, picks something up from the ground and turns around – using ratio scales when possible. The BBS has a test-retest reliability of 0.98 and an inter-rater agreement of 0.98. The BBS correlates well with the Barthel Index at 0.98 and with TUG scores at 0.70. This test has been proven to be sufficient for assessing different target populations, such as the elderly (Steffen *et al.* 2002) and

stroke patients (Steffen *et al.* 2002; Blum & Korner-Bitensky 2008). The BBS was considered to be suitable for participants with SMD because it assesses a person's functional balance during daily situations, which can be scored independently by observing the participant's spontaneous movements throughout the day. This way of scoring eliminates the risk of a patient not understanding the task. Yet, a few practice sessions showed some tasks to be too difficult for the participants, which led to a slight adaptation of the protocol by excluding four and adding two items. We coined the adapted BBS the modified Berg Balance Scale (mBBS). With these adaptations, the mBBS seems to be feasible for assessing balance in our target population.

To sum up, out of the five potential tests the literature search put forward, solely the BBS seems suitable for our target population, albeit only in its modified version. Hence, the purpose of this study was to evaluate the feasibility and reliability of the mBBS in persons with intellectual and visual disabilities classified Gross Motor Function Classification System (GMFCS) grades I and II.

Methods

Participants

Participants were recruited from a residential care facility for the profound or severe intellectually and visually disabled in the Netherlands. Of the residents of this facility, 65% also suffer from motor disabilities. The participants were classified according to their motor skills using the GMFCS (Palisano *et al.* 2000), a five-level system used to classify the motor abilities of the physically disabled. Participants with a 'level I' classification can generally walk without restrictions but tend to have limitations in more advanced motor skills. Participants with a 'level II' classification can walk with slight restrictions and do not spontaneously increase their speed during walking. The locomotor skills of those assigned GMFCS levels III to V are very limited and they were therefore excluded from performing the balance test.

Written consent was requested from the representatives of 92 candidates and obtained from 80. After informed consent was obtained, the subjects were screened based on an examination by both a special needs physician and a behavioural scholar. The

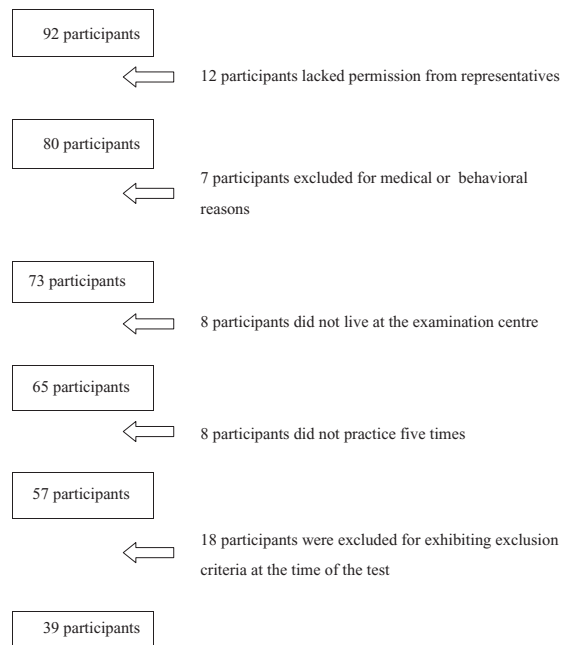


Figure 1 Inclusion steps.

screening itself excluded seven subjects. Another eight participants were excluded, as they did not live at the centre where the tests were to be performed. Eight other participants were excluded as they could not attend all five practice sessions. Another 18 participants were excluded as they exhibited one or more of the exclusion criteria at the time of measurement (Fig. 1). These exclusion criteria were: psychoses, depression or other severe psychological problems; somatic diseases, which were defined as chronic diseases and/or diseases that do not resolve in the short term (e.g. osteoarthritis, osteoporosis, pneumonia, etc.); general illness or fever; taking antibiotics; worsening of asthma, epilepsy (recent insult or epileptic fits), fresh wound(s)/bruise(s) or other factors causing pain during movement, and finally stress because of the participant's behaviour shortly prior to the date of measurement.

Out of the remaining 39 participants in this study, 28 were male and 11 were female. The mean (SD) age was 38 (11) years for the men and 44 (10) years for their female counterpart. Twenty-three participants were classified GMFCS level I and 16 participants GMFCS level II. According to the classification scheme of the ICD-10 (WHO 1992), 92%

($n = 36$) had severe ID and 8% ($n = 3$) suffered from profound ID. According to the WHO (2001) guidelines, all participants suffered from impaired vision: 44% ($n = 17$) of the participants was severely partially sighted, 38% ($n = 15$) was partially sighted and 18% ($n = 7$) was slightly limited in sight. Most participants had impaired motor abilities: 67% ($n = 26$) had orthopedic defects and 5% ($n = 2$) had severe motor handicap of neurological origin. In addition, 23% ($n = 9$) of the participants had slight hearing problems, 2% ($n = 1$) had loss of hearing and 5% ($n = 2$) either had severe hearing loss or was completely deaf.

Design

The participants performed the mBBS twice, with a 1-week interval between test and retest. Both tests were performed at the same time of day, under the same circumstances and under the supervision of the same personal caretaker and observer.

Ethical statement

The study was performed in agreement with the guidelines of the Helsinki Declaration as revised in 1975. Permission was obtained from the institutional ethics committee. Informed consent was obtained from the legal representatives of the participants, as the participants themselves were unable to give consent. The measurements were performed in accordance with the guidelines of the Dutch Society of Special Needs Specialists (NVAZ) which are outlined in a code called 'Resistance among people with an ID in the framework of the Act Governing Medical-Scientific Research Involving Humans' (NVAZ 1999). This code intends to guide doctors in assessing resistance in persons with an ID. Following this code, consistent distress or unhappiness of the participant was interpreted as a sign of lack of assent, and further participation in the study was reconsidered.

Measures and protocols

Prior to the measurements, the observers and personal caretakers of the participants completed a checklist that included all exclusion criteria. Participants were to be excluded from the study if they

exhibited any of the exclusion criteria at the time of measurement.

As familiarisation, the participants practised five times prior to formal testing. As Hale *et al.* (2007) have noted, allowing a participant to become familiarised with both test and tester may ease problems concerning misunderstanding of the required tasks ahead. In these practice sessions, the following tasks were found too difficult for the participants to perform: tandem standing, reaching forward while standing, turning one's trunk while feet are fixed and standing with eyes closed. Therefore, the protocol was slightly adapted by excluding these four components while adding two new items: walking on a thin line and walking on a gymnastic beam (width 30 cm, 40 cm above the floor). These two items were added as the participants were already familiar with these tasks. We coined the adapted BBS the mBBS. Including the aforementioned adaptations, the feasibility and test–retest reliability of the mBBS were examined. The mBBS consisted of 12 items, as shown in Table 1. The performance on each of these items was scored on a 5-point ordinal scale (0–4 points), where a score of 0 denotes the inability of the participant to perform the task, and a score of 4 is assigned when the participant is able to complete the task based on the criterion that has been assigned to it. The maximum score of the mBBS is 48 points. If a subject did not understand a task, the score of that task was excluded from the total score.

Table 1 The 12 items of the mBBS

Number	Test item
1.	Sitting unsupported
2.	Change of position: sitting to standing
3.	Change of position: standing to sitting
4.	Transfers
5.	Standing unsupported
6.	Standing with feet together
7.	Turning 360 degrees
8.	Retrieving objects from floor
9.	Stool stepping
10.	Walking on a thin line
11.	Standing on one leg
12.	Walking on a gymnastic beam

mBBS, modified Berg Balance Scale.

During testing, two observers completed the score forms independently and a personal caretaker instructed the participants. In total, two observers and four caretakers participated in the study. The observers were physiotherapist students, who performed the study for their bachelor thesis and were supervised by the first and second author. All observers and caretakers were instructed during two separate training sessions so as to ensure consistency among them. The first training session was supervised by the first and second author and took 2 h. The protocol of the original BBS was the topic of the first training session and a detailed manual was provided to each observer. During the five aforementioned practice sessions, both the observers and caretakers practised using the instructions and scoring procedures. The scoring procedure was accurately determined and the scores of the two observers were compared. The level of consistency appeared to be sufficient. After the aforementioned adaptations of the BBS protocol, the second training session was organised with the adapted protocol, which was supervised by the first and second author too. This training session focused on the two new test items.

Data analyses

The data were analysed using SPSS 14.0.

Feasibility

To assess feasibility, we held the number of successful measurements per task against the total number of measurements. As it only makes sense to use a test if there is a reasonable percentage of successful measurement, feasibility was considered to be sufficient if 85% of the measurements were successful (Malmberg *et al.* 2002).

Test–retest reliability

To determine the test–retest reliability, we computed intraclass correlation coefficients (ICC; two-way random, absolute agreement). Reliability was considered to be moderate, if the ICC was between 0.41 and 0.60, strong if the ICC was between 0.61 and 0.80, good if the ICC was greater than 0.81 (Feinstein 1987) and very good if the ICC was greater than 0.90 (Portney & Watkins

2000). To assess the internal consistency between the 12 test tasks, we computed Cronbach's alpha. Internal consistency was acceptable if Cronbach's alpha was 0.70 or more (Field 2005). To analyse the level of agreement between the scores for test and retest of the distinct tasks, the proportion of equal scores and its Wilson confidence intervals (CI) were computed, as suggested by Brown *et al.* (2001). The level of agreement was considered to be sufficient if the proportion of equal scores is 0.80 or more and the Wilson CI (95% CI) are between 0.60 and 1.0. Furthermore, we computed the power of the study with the hypothesis that the population proportion of agreement is 0.50, taking a one-sided test and sample size 39 (Brown *et al.* 2002; Dorai-Raj 2009).

Modified Berg Balance Scale scores

In the BBS, a score of 80% (45 points) indicates sufficient balance (Berg 1989). However, this cut-off value cannot simply be applied to the mBBS, as the modifications influence the cut-off value and thus render a comparison meaningless. For that reason, we will describe the scores of the participants without the cut-off values.

Results

Feasibility

Tasks 1, 3, 4, 7 and 8 were completed by all 39 participants; tasks 2, 5 and 12 by 38 participants, tasks 9 and 11 by 37 participants, and tasks 6 and 10 by 36 participants (Table 2). Thirty-six out of 39 participants (=92%) completed all tasks. The duration of the test was about 30 min.

Table 2 Percentage successful mBBS measurements in GMFCS levels I and II participants ($n = 39$)

	Tasks 1, 3, 4, 7, 8	Tasks 2, 5, 12	Tasks 9, 11	Tasks 6, 10
Percentage successful measurements	100%	97%	95%	92%

GMFCS, Gross Motor Function Classification System; mBBS, modified Berg Balance Scale.

Test-retest reliability

Table 3 summarises the medians of test and retest, the results of the ICC analysis, and the proportion of equal scores.

The ICC for the tasks 1, 4 and 5 was considered moderate, for the tasks 2, 7, 9, 10 strong, for the tasks 6, 8, 11, 12 and the total score very good, whereas the ICC for the task 3 could not be computed, because the scale has zero variance items. The ICC for the total score without tasks 9 and 10 was 0.97 (0.94–0.98), which is very good. Cronbach's alpha for tasks 1–12 was 0.84. The obtained proportions of equal scores were greater than or equal to 0.80 with Wilson 95% CI between 0.60 and 1.00 for tasks 1, 2, 3, 4, 5, 6, 7, 8, 11 and

Table 3 Medians of test and retest, results of the ICC analysis with 95% confidence intervals (CI), and the proportion of equal scores with Wilson CI

	Median test	Median retest	ICC* 95% CI	P of equal scores 95% CI
Task 1	4	4	0.68 0.40–0.84	0.82 0.67–0.91
Task 2	4	4	0.76 0.53–0.88	0.84 0.69–0.92
Task 3	4	4	Could not be computed	0.97 0.87–1.00
Task 4	4	4	0.45 –0.46–0.71	0.90 0.76–0.96
Task 5	4	4	0.64 0.31–0.81	0.84 0.70–0.93
Task 6	0	0	0.91 0.81–0.95	0.88 0.72–0.95
Task 7	4	4	0.74 0.49–0.86	0.90 0.76–0.96
Task 8	2	2	0.99 0.98–0.99	0.92 0.79–0.97
Task 9	3	3	0.86 0.72–0.93	0.68 0.51–0.81
Task 10	2	2	0.72 0.48–0.86	0.54 0.39–0.68
Task 11	0	0	0.95 0.89–0.97	0.83 0.67–0.92
Task 12	4	4	0.98 0.95–0.99	0.94 0.82–0.98
Total score	35	35	0.95 0.92–0.98	–

*Two-way random; total agreement.
ICC, intraclass correlation coefficients.

12 (Table 3). However, the proportion of equal scores was <0.80 for tasks 9 and 10 and the Wilson CI were wider than 0.40 for these tasks too. The power analysis revealed a power of 0.91 with the hypothesis that the population proportion of agreement is 0.50 and the alternative and true agreement is 0.75 (Brown *et al.* 2002; Dorai-Raj 2009).

Modified Berg Balance Scale scores

The median score of the GMFCS level I participants was 36 (24–47) and that of the GMFCS level II participants 29 (17–44).

Discussion

As to date, it is unclear which specific balance test can be feasibly and reliably used for individuals with SMD. The results of the present study show that the feasibility of all mBBS tasks was acceptable for participants with SMD and GMFCS levels I and II. The test–retest reliability assessed with the ICC was acceptable for 7 of the 12 mBBS tasks (indicating strong to very good reliability), as was the total score. Of the tasks 1, 4 and 5, the ICC was moderate. The level of agreement assessed with proportion of equal scores was acceptable (higher than 0.80) for 10 out of 12 mBBS tasks. The proportion of equal scores for tasks 9 and 10 was lower than 0.80. Taken the ICC and the proportion of equal scores together, we consider the reliability of the mBBS sufficient, except for tasks 9 and 10. The reliability of the total score computed with ICC when correcting for tasks 9 and 10 was very strong. Internal consistency between the tasks was acceptable.

The mBBS appears to be a feasible and suitable test, given the challenges in obtaining test results from participants with severe intellectual and visual disabilities (Hale *et al.* 2007).

The reliability of 10 of the 12 mBBS tasks (ICC 0.97) was comparable with the reliability of corresponding BBS tasks reported in other studies with other populations: a very good intratester reliability was found by Berg *et al.* (1989) in the elderly (ICC 0.97) and by Liston & Brouwer (1996) on stroke patients too (ICC 0.98). The study of Blum & Korner-Bitensky (2008) on stroke patients reported an ICC of 0.97 for test–retest reliability. This is

considered a satisfactory result for test–retest reliability too, given the aforementioned difficulties in obtaining test results from participants with SMD (Hale *et al.* 2007).

In the present study, Cronbach's alpha was 0.84 for the mBBS, which is less reliable than the Cronbach's alpha of 0.98 reported by Blum & Korner-Bitensky (2008). Nonetheless, our Cronbach's alpha value is still within the acceptable range, according to Field (2005).

The proportion of equal scores for the test–retest of task 9 was relatively low, which might be explained by the fact that the subjects had trouble understanding task 9, which involved stepping onto a seat. It was observed that subjects, placing one foot on the seat, either intuitively placed the other foot on the seat next to their first foot as if climbing stairs, or intuitively stepped over the seat. Task 11, standing on one leg, which is also included in FICSIT-4 (Rossiter-Fornoff *et al.* 1995), could act as a feasible and reliable alternative for task 9, as both tasks require a subject to stand on one leg.

Also the proportion of equal scores for the test–retest of task 10 was relatively low. Performing the task of walking on a thin line proved difficult for the subjects, who often were not able to see the line. It was tried to solve this problem by replacing the line by a thin rope, but it was found that the subjects still did not manage to complete the task. Task 12, walking on a gymnastic beam (width 30 cm, 40 cm above the floor), could act as a feasible and reliable alternative. Participants are more familiar with this task and it would therefore ease problems concerning understanding. Considering these observations, we recommend excluding tasks 9 and 10 because of their low proportion of equal scores and their relatively low percentage of successful measurements. The ICC of tasks 1, 4 and 5 was moderate, although the proportion of equal scores was acceptable. Furthermore, these tasks also proved to be feasible. Taking these findings into consideration, we recommend sustaining tasks 1, 4 and 5 in the mBBS. Consequently, the final mBBS consists of 10 tasks.

According to Berg *et al.* (2008), the BBS cannot reliably estimate the probability of falling. For that reason, we propose to use the mBBS for evaluating the effects of intervention on balance.

However, for this purpose, future research should aim to examine the sensitivity to change of the mBBS. We have the impression that the mBBS has floor and ceiling effects, implying that the mBBS may not always detect meaningful changes when evaluating an intervention. These effects are also described by Blum & Korner-Bitensky (2008). However, there were differences between the median scores of the GMFCS level I and level II participants, 36 to 29, respectively. This might be indicative of the potentials of the mBBS to be discriminative. Further research on these topics may be useful.

A rather small number of participants participated in the present study, which could be a limitation. However, given the width of the Wilson CI of the proportion of equal scores, the power is sufficient except for tasks 9 and 10 (Brown *et al.* 2002; Dorai-Raj 2009). Furthermore, our power analysis revealed a sufficient power of 0.91, with the hypothesis that the population proportion of agreement is 0.50, the alternative and true hypothesis is 0.75, taking a one-sided test and sample size 39 (Brown *et al.* 2002; Dorai-Raj 2009). Although 65 subjects were initially included in the study, only 39 met all inclusion criteria and were able to complete both test and retest. Some were excluded because they were unable to perform the mBBS test and retest within 1 week, others because they exhibited one or more of the exclusion criteria during retesting.

In conclusion, the results show that the mBBS is a both feasible and reliable test for evaluating the functional balance of individuals with severe intellectual and visual disabilities.

Even though the BBS is widely used, its reliability for individuals with SMD had not yet been evaluated. This research extends the knowledge for researchers and clinicians in the field using the BBS. As mentioned, using a modified version of the BBS rendered the standard BBS cut-off scores meaningless. Further research should aim to develop cut-off values for the mBBS, to examine the validity of the mBBS, including the sensitivity to change, and the presence of floor and ceiling effects. Furthermore, research focused on the development of interventions aimed at improving balance control in persons with SMD is recommended.

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